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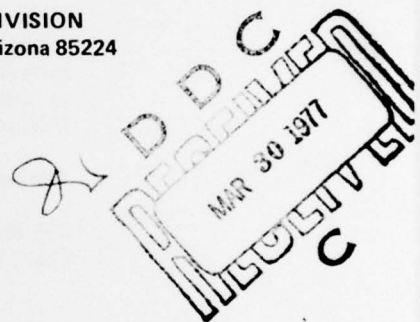


**DEVELOPMENT OF A SYLLABUS AND STUDENT/INSTRUCTOR
GUIDE FOR USE WITH A FULL MISSION SIMULATOR**

By

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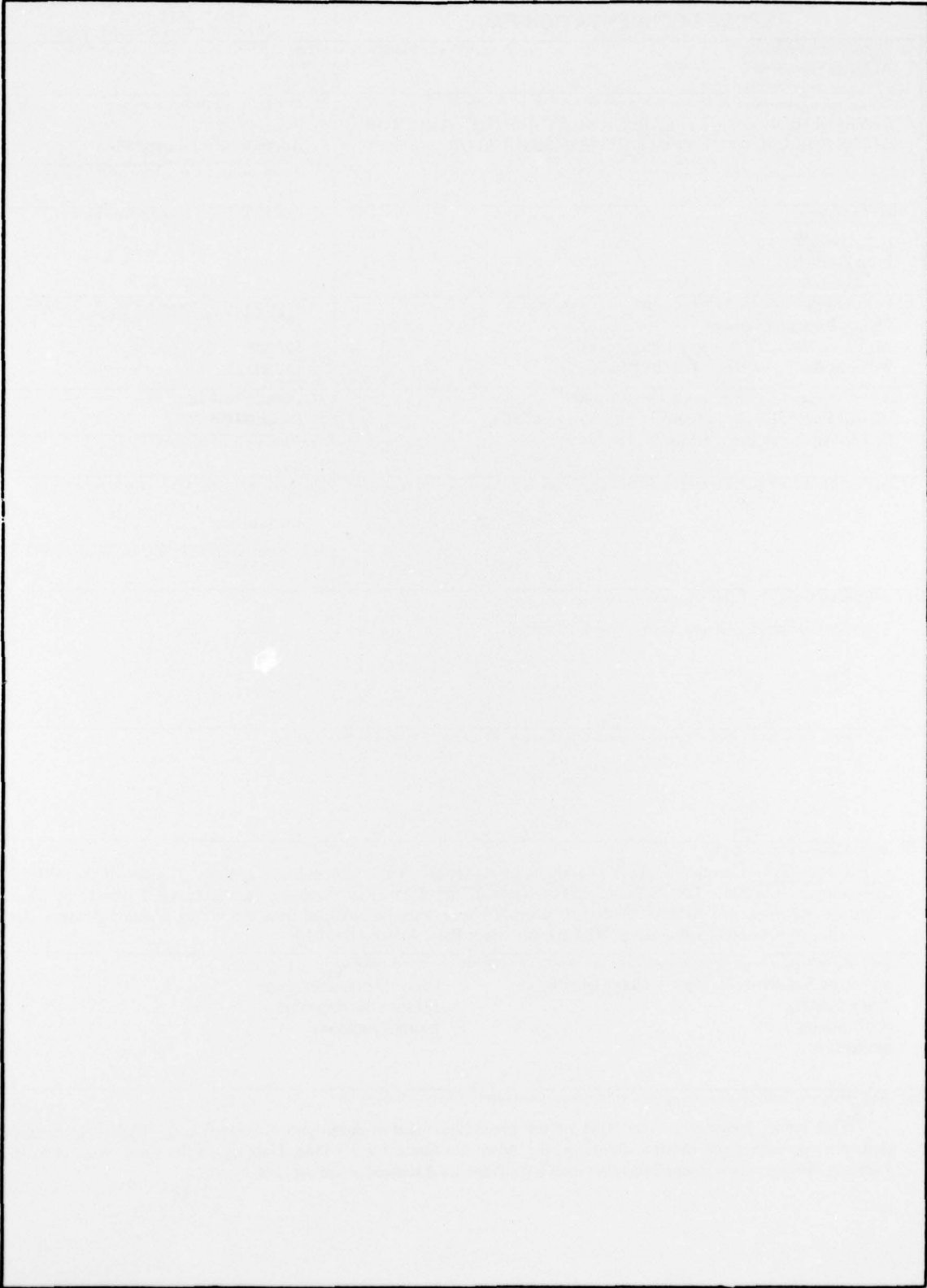
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PREFACE

This study was conducted in support of project 1123, Flying Training Development, Dr. William V. Hagin, Project Scientist; task 112303, The Exploitation of Simulation in Flying Training, Mr. James F. Smith, Task Scientist; and work unit 11230321, ASPT Operational Utilization Test, Mr. Robert R. Woodruff, Principal Investigator, assisted by Captains Stephen K. Rust, John H. Muller, and Douglas C. Weyer.

This study was conducted by the Flying Training Division of the Air Force Human Resources Laboratory (AFSC) and supported by the 82d Flying Training Wing (ATC) and 82d Flying Training Wing/Deputy for Operational Research commanded by LtCol Gerald L. Floyd.

Special appreciation is expressed to LtCol Floyd and his staff who conducted the student training phase of this study. These individuals were: Captains Lewis V. Lake and John W. Stephens and Lieutenants James H. Gormley, Lucian A. Dade, III, Thomas I. Beil, Robert N. Cleveland, and Lee A. Leshner. In addition, superior HQ ATC support was provided through the efforts of Captain James D. Beggerly, ATC/DOY.

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DEVELOPMENT OF A SYLLABUS AND STUDENT/INSTRUCTOR GUIDE FOR USE WITH A FULL MISSION SIMULATOR

I. INTRODUCTION

In early 1975, the Flying Training Division of the Air Force Human Resources Laboratory (AFHRL) planned implementation of an exploratory study involving use of the Advanced Simulator for Pilot Training (ASPT) (formerly ASUPT) as a full mission simulator for the basic (T-37 aircraft) phase of undergraduate pilot training (UPT). The ASPT was particularly suited for this operational utilization test (OUT) since it was the only device in existence at the time equipped with a six-degree of freedom synergistic motion system, a full wraparound visual system and a full complement of advanced training features.¹ The exploratory OUT involved application of the ASPT capabilities in all categories of T-37 UPT including: Basic formation, instruments, contact and navigation. Previous research using the T-4G simulator² provided an estimate of the amount of training transfer that can be achieved through use of a more limited device (Woodruff & Smith, 1974) and provided guidance and information for use in the design and conduct of the OUT; similar information involving contact training was not available from any source.

Training transfer achieved through use of the ASPT was estimated by determining to what extent simulator training could be substituted for flight training in each category of UPT. A sample of UPT students was trained to proficiency in the ASPT; they were then trained to proficiency in the aircraft. All students received aircraft instrument and contact checks near the end of T-37 training. At completion of the OUT, all students entered T-38 training (advanced UPT) with their regular class.

An essential element for successful accomplishment of this study was the development of a revised UPT syllabus which provided for sequencing of simulator and aircraft training and related academics throughout the total flying program as opposed to conventional simulator usage involving only cockpit procedures and instrument training.

This report provides a description of procedures involved in designing the special syllabus and in preparing the student/instructor guides used in the OUT. Training effectiveness results achieved in the study are included only where they relate to the effects of the syllabus and recommendations for follow-on applications; complete results of the study are described in a separate report (Woodruff, 1976).

Copies of the ASUPT Operational Utilization Test Syllabus, ATC Conventional T-37 Phase Training Standards, OUT Master Syllabus Schedule and Flow, and AFHRL Student/Instructor Guide, may be obtained from Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224.

II. SYLLABUS DEVELOPMENT

Objectives

The syllabus was designed to meet the objectives of the exploratory study as well as to satisfy all Air Training Command (ATC) student training requirements for the T-37 phase of UPT. Specifically, the objectives for the syllabus development were as follows:

1. Insure that each student pilot received training which, as a minimum, was equal to that provided under the current ATC Syllabus P-V4A-A, July 1975.
2. Provide training in the simulator that would allow reducing the number of flying hours in the T-37 to the minimum commensurate with objective one above.
3. Develop syllabus concepts for use in the UPT Instrument Flight Simulator (IFS). This included determining an estimate of simulator training time required to reach proficiency in instruments, navigation, and basic contact airwork and landings.

¹ For a more detailed description of the ASPT, see Hagin and Smith, 1974, pages 17-26.

² The T-4G simulator incorporates: a two-degree of freedom motion system, a T-37 aircraft cockpit, one color CRT with infinity optics and a filmed scene; see Hagin and Smith, 1974, pages 26 and 27 for more detail.

4. Provide a sufficiently controlled program of training to allow a comparison between students in the OUT and students in normal UPT.

Constraints

Subjects used in this study were assigned to ATC and had to meet all standard requirements established by the ATC conventional course of training. Constraints resulting from those requirements that significantly affected syllabus development were as follows:

1. Students had to finish the T-37 phase of training within the same number of training days required by the other members of their class.
2. Students had to take the same academic courses on the same schedule as the other members of the class.
3. Aircraft had to be scheduled in the same manner as aircraft used in the conventional ATC program. This usually required a two-week lead time for requesting aircraft flights.
4. Each student was required to fly at least four hours in the last 20 training days prior to proceeding to T-38 training.

Training Concepts

In developing the syllabus, experience gained through previous research with the T-4G and with the advanced instructional capabilities of ASPT was used. The report on syllabus development for the T-4G (Rust, Smith, & Woodruff, 1974) provides some background on the training strategies employed; the specific concepts used and outlined below are drawn from that report. While they may not necessarily be implemented for future operational training, they were deemed necessary to meet the objectives of this study.

Training Manager Concept. Instructor pilots (IP) were assigned to students on a one-to-one basis. This allowed each instructor to more closely monitor the progress of his student, schedule remedial training where required, and evaluate the effects of simulator capabilities on training and on transfer to the aircraft.

Blocked Training. An inventory of each task to be learned by the student during the T-37 phase was compiled. In certain instances, new tasks were introduced when it was felt that they would enhance the learning process. New tasks that could normally only be done in the simulator, such as low visibility approaches or in-flight emergencies, were also introduced when it was believed they could improve the overall pilot ability and confidence of the student. Each task was then prioritized, based on difficulty, so that it could be presented in a logical training sequence. Tasks were grouped in instructional units so that a student would have to finish one unit before advancing to the next. This process was applied for each maneuver in the five training categories: (a) basic, (b) contact, (c) instruments, (d) formation, and (e) navigation. The OUT Master Syllabus Schedule and Flow details the maneuvers assigned to each block of training.

Performance Standards. Performance standards for each category of training were the same as those established in the ATC Conventional T-37 Phase Training Standards. Students had to achieve the ATC *Safe/Satisfactory* level of proficiency in the simulator before advancing to the aircraft. They then had to meet these same minimum standards in the aircraft before their performance was considered satisfactory for purposes of this study.

Proficiency Advancement. Students were progressed through each phase of training as rapidly as possible based on their ability to meet the specified performance standards. This approach was adopted to provide a determination of the minimum amount of training time required in the simulator and in the aircraft; however, since certain academic prerequisites were required for each group of tasks, and since the academic flow was fixed, the syllabus flow had to be adjusted to minimize the possibility of a student being ready to advance in flight training without having met the appropriate academic prerequisites. In addition, prerequisites in ground and flying training were incorporated into the syllabus to ensure that each student had an equivalent amount of training in each category prior to his aircraft checkrides.

Team Training. This concept allowed one student to observe and be involved in the training of another. The conventional syllabus included this concept during aircraft flights in the T-38 phase of training. Previous research by the Flying Training Division indicated that the observer benefited most by

observing procedural tasks before accomplishing them. In addition, students who performed while being watched by their peers tended to exhibit superior performance (Woodruff & Hagin, 1973). For these reasons, three team sorties were included in simulator training during procedural training and one team sortie in the navigation category.

ASPT Training Features

In addition to providing a capability for instructors to operate from either inside the simulator cockpit or outside the cockpit at the console, the ASPT also possesses several advanced instructional features. These include: selective task sequencing, variable task difficulty and complexity, selective malfunction insertion, freeze, rapid initialization, automated demonstration, knowledge of results and self-confrontation. Following is a brief description of those used in this study.

Task Difficulty and Complexity. Any given task may have several levels of difficulty and complexity. In this study three capabilities were used. First, the *motion system*, with all six degrees of freedom operational, was used with half the students; the other half were trained using no motion. Second, selected *malfunctions* were used to provide training and to increase task loading during the later stages of training. Third, *environmental factors* including wind direction and velocity and turbulence were used for training and to increase task loading.

Freeze. The freeze mode used in this study is similar to existing simulator capabilities. Its selection by the student's instructor stops the simulator; all instruments and visual displays stop in their last position. This capability gave the student time to catch up, let the instructor's briefing remain current with the aircraft, or let him emphasize a particular point.

Reinitialization. This is the ability of the system to place the simulated aircraft at a particular point in space and with a given configuration without "flying" it there. For example, in learning the turn to final, the student could start from the downwind, fly to touchdown, reinitialize back to the downwind, and attempt the task again. This permitted maximum practice of the prescribed maneuver in the allotted time.

Automatic Demonstration. This capability permits the student or instructor to call for the demonstration of a selected maneuver or a part thereof. "Perfect" maneuvers were recorded and stored for this use. Playback provided all motion cues, instrument readings, and visual scenes of the total simulator system. Recorded audio instruction was synchronized with the visual display and accompanied the playback when desired. Portions of the maneuver could also be selected in a similar fashion. This capability provided for standardization of maneuvers and instructional techniques. In addition, it permitted students to see and then practice without an instructor present.

Knowledge of Results. Students could be provided knowledge of results on their performance in several ways. Available techniques include performance playback, cathode ray tube (CRT) presentation, descriptions of performance or any combination of these. Any or all of these capabilities were used at the discretion of the instructor.

Self-Confrontation. This capability permits the student to examine his own performance through a playback of that performance using all systems including stick, throttles, and rudder. This playback could be presented in slow or real time, but only real time playbacks were used in this study.

Approach

In accordance with instructional system development strategies, an important consideration in constructing the syllabus was to determine the appropriate media for each category of training. In consideration of training costs, it was decided to conduct preflight training in the conventional T-4 trainer (a fixed-base procedures and instrument trainer and the T-4G). This phase occurred during the first 17 days of training, while the students were in the preliminary academic courses. The subjects received training in basic aircraft control and basic maneuvers. This part of training was essentially the same as normal ATC training, with the exception of a provision to allow for proficiency advancement.

During the remainder of the 81 training days allotted for conventional ATC T-37 training, the T-4 trainer was considered as strictly a cockpit procedures trainer. Normal and emergency procedures were taught in the T-4 (with the exception of one team emergency procedures ASPT sortie) since this was a more cost-effective medium than ASPT for this type of training; all simulator flying training was conducted in the ASPT.

The syllabus was arranged so that all students were trained in the simulator to ATC standards in presolo contact before going to the aircraft. A simulator checkride was included to ensure that these standards had been met before the student's first aircraft flight. It became evident during syllabus formulation that, while not desirable, minimum and maximum numbers of sorties in each instructional unit had to be specified to integrate the syllabus flow with academic prerequisites. Although sortie limits for the simulator could not be set with certainty, information from the T-4G studies (Woodruff & Smith 1974; Rust et al., 1974) and task frequency information from the T-4 and the aircraft (Brown & Rust, 1975) was useful in specifying these limits. These limits were adjusted somewhat as experience was gained during the study.

The general philosophy during the study was to train to proficiency in the simulator before advancing to the aircraft. The final syllabus flow was evaluated by estimating the effects on continuity of hypothetical excellent, average, and slow students progressing through the program on a proficiency basis. Although it was determined that some poor continuity might result due to prerequisites, it was expected that advanced planning and efficient scheduling based on early identification of fast or slow students, could minimize these effects.

The final arrangement of training categories was very similar to the conventional syllabus flow due to the necessity to meet academic prerequisites. The OUT Master Syllabus Schedule and Flow lists all missions to be accomplished by training day, as well as mission prerequisites. The training flow is provided in the AFHRL Student/Instructor Guide.

III. STUDENT/INSTRUCTOR GUIDE DEVELOPMENT

Objectives

The AFHRL Student/Instructor Guide (SIG) was developed to insure that training in ASPT was conducted in an efficient and uniform manner. It was designed to help the students prepare for simulator training, assist in the conduct of training, and reinforce student learning after the training was accomplished. This type of guide had been used in previous research and was expected to serve as a basis for future advanced simulator training guides.

Approach

The systems approach to training was utilized in designing the SIG. The desired behavioral objectives for each task trained in the simulator were listed. All other items in the guide were intended to assist the student and instructor in accomplishing these task objectives.

Student activities were listed for preflight, in-cockpit, and postflight. References directed the student to all relevant source materials including learning center programs pertaining to each specific task. Probable errors, based on experienced IP judgments, were also included to alert students to common pitfalls normally encountered while performing each maneuver.

Suggested IP activities were included to remind the instructor of the advanced training features that could or should be used for each task. In addition, a variety of training techniques and instructions for setting up the simulator were listed.

The SIG also contained special instructions for each block of training, personal equipment to be worn by the subject on each mission, and special instructions for use of task maneuver data cards.

IV. FINDINGS AND DISCUSSION

Student Performance

While not essential to this report, a summary of the results achieved by the OUT subjects is included for information. Subjects in the OUT required an average of 59 ASPT hours³ to complete all phases of

³ All hourly requirements included in this report have been rounded to the nearest whole number.

training. Simulator hours required by category of training were as follows: Basic and Presolo, 19; Advanced Contact, 6; Night Flying, 1; Instruments, 24; Formation, 2; and Navigation, 8. For purposes of comparison, students trained in the conventional UPT syllabus used 14 hours of T-4 trainer time for Instruments and 3 hours for Navigation for a total of 17 hours. (Neither total hour figure; e.g., 59 ASPT or 17 T-4, include some simulator hours used during preflight for cockpit procedures training).

Pre-study estimates of simulator time requirements proved to be reasonably accurate. There was one exception and that was in Formation. Specified performance standards for the ASPT were not met in the formation category. Early student training efforts revealed that the ASPT was significantly more difficult to fly in formation than the aircraft. Both IP's and students expressed doubt as to the simulator's training effectiveness in formation; as a result, only a few simulator formation sorties were flown and three students received no formation training in ASPT.

Several important findings concerning proper simulator utilization strategies resulted from this study and were reported by Woodruff (1976). One of these impacts syllabus development; a simulator check ride should be an integral part of the training program.

The OUT subjects completed the basic phase of UPT using 20 less T-37 hours than conventionally trained students (91 versus 71 hours). The majority of these savings occurred in: Basic and Presolo, 11 hours (45%); and Instruments, 5 hours (39%). Other categories of training in which some less significant savings were achieved were: Navigation, 1 hour (13%); Formation, 1 hour (13%); and Advanced Contact, 1 hour (04%). While these savings give some indication of simulator training effectiveness, such interpretations are not completely valid since control group students proceeded on a fixed schedule; thus, some students may have met the specified standards in less than the total specified hours they received.

Average T-37 aircraft check ride scores (instruments and contact) achieved by experimental and control group students were compared to obtain a relative estimate of the quality of training received. For instruments, the scores were basically alike (89.75% versus 89.82%). On the contact check, the OUT students performed significantly better ($p < .01$) than the control group (90.85% versus 87.35%, respectively). The performance of all subjects was followed up in T-38 training and the difference in success on the contact check ride was repeated with the same level of confidence (i.e., 91.77% versus 86.88%; $p < .01$).

Syllabus Flow

Several problems were encountered during the conduct of the study which resulted directly from the constraints listed in Section II. Those associated with scheduling were readily apparent; others were identified through frequent interviews/discussions with the instructors and students during the conduct of the study. Many of the problems occurred as a result of attempting to adapt proficiency advancement into a training and equipment scheduling system which normally operates on a fixed-schedule basis. As a result, student training continuity was sometimes lost. Students often had to wait to complete certain academic prerequisites before they could advance to subsequent instructional units. In addition, other prerequisites, added to insure uniform progress through training for all students, severely restricted the scheduling flexibility. Since this was an exploratory study, these later prerequisites were revised after problems with faster moving students were encountered and thus may have reduced the training effectiveness estimates achieved.

Proficiency Advancement. The application of this concept caused more difficulty than anticipated. Proficiency advancement was applied with considerably fewer problems in the instrument category in the T-4G studies referenced earlier and also on a larger scale application in instrument training for an entire class (Woodruff, Mullen, & Winans, 1974). The interaction of different rates of advancement in all categories of training with a fixed academic schedule was the primary cause of the difficulties encountered. This suggests that if the concept of progression on a proficiency basis is to be used in research projects, the scope of the projects should be limited to single categories of training, thereby reducing the potential problem area. Further, if the concept of proficiency advancement is to be implemented in a total flying training program, a more flexible academic program will be required.

Performance Standards. As discussed earlier, students were required to meet the ATC Safe/Satisfactory performance standards in the simulator prior to advancing to the aircraft. Based on IP's opinions, these standards were inappropriate in several instances. For example, they felt that there was very

little transfer from the simulator to the aircraft in the flare and touchdown portion of the traffic pattern. The time spent achieving the *Safe/Satisfactory* level of proficiency on landing was probably wasted, since the transfer to the aircraft was minimal.

The formation category of training is another example wherein proficiency levels established for use in the simulator were questionable. While research with the formation flight trainer indicated that positive transfer could be expected in formation (Reid & Cyrus, 1974), the ASPT formation flying capability was inadequate (in the opinion of the instructors and students) to produce significant training. As a result of the difficulties encountered, formation criteria were deleted and training in this category made optional.⁴

Basic/Contact Training. Both IP's and students felt that basic and presolo contact training in ASPT were very beneficial; transfer of training results support this position. These data support the general concept that syllabi designed for beginning students or for transitioning to a new aircraft should include simulator time prior to flight. The instructors also believed it was helpful to come back to the simulator for extra training if the students had difficulty in the aircraft. The advanced training features of the simulator allowed repetitive practice on specific problem areas which was not possible in the aircraft. Allowance for this type of remedial training, at the instructor's discretion, should be included in any future syllabus designed to incorporate the use of a full-or part-task mission simulator.

Instrument Training. The results of the instrument category of training are of importance to personnel developing a syllabus for use with the new instrument flight simulator for UPT. Six students were instructed in instruments from the console. Four of these students failed their aircraft check ride on the first attempt. As a result, the remaining two students received the majority of their training with the instructor in-cockpit and these students passed their first aircraft check rides. While the evidence is not conclusive, it tends to indicate that the in-cockpit instructor can observe the student better and thus provide better instruction on basic crosscheck and instrument procedures.

Additional problems were generated by the instrument check failures. Each failure required some amount of additional simulator and aircraft practice time. Since aircraft sorties were required to be scheduled two weeks in advance, this review required aircraft scheduled for advanced contact training to be diverted to instrument sorties and the contact training delayed. This problem is directly related to the aircraft scheduling constraint (stated earlier) and provisions for increased flexibility are required before the concept of proficiency progression can be adopted. In this particular study, the "snowball" effect of aircraft rescheduling also impacted students scheduled for contact flights with the result that training effectiveness estimates for the ASPT in the area of contact training were undoubtedly reduced.

The participants in the study suggested changes to the syllabus flow which they believed would improve performance. These suggestions were:

1. The instrument check should be given closer to the end of T-37 training. This would allow the student more time in the aircraft prior to the check and reduce the apprehension and task overloading that seemed to occur during the instrument check rides.
2. All navigation training in the aircraft should occur prior to the check. This would allow students more exposure to hooded instrument type training in the aircraft before the check ride.
3. Passing an instrument check ride in the simulator should be a required syllabus element and should be accomplished prior to the aircraft check ride. While an instrument check ride was given in the simulator, it was not a matter of official record and, due to scheduling difficulties, it did not always occur prior to aircraft training. The simulator check would ensure that performance standards had been met prior to aircraft training. In addition, it would be desirable to have the student's instructor monitor the check to enable him to better conduct remedial training—if necessary.

Navigation Training

The navigation training was thought to be excellent by instructors and students. Of particular interest was the team navigation sortie which was monitored by the instructors. Students were exposed to a new environment of problem solving and decision making which they do not normally see in local area flying or cross-country flying with an IP. Although the students made false starts and took time coordinating their

⁴Subsequent analysis of training effectiveness data as reported by Woodruff (1976) suggests that despite the difficulties involved, positive transfer did occur as a result of ASPT formation training.

efforts, they were eventually able to complete the mission. In so doing, they learned the skills required and gained confidence in their own abilities. While this conclusion is very subjective, it was supported by all the students.

Student/Instructor Guide

As expected from previous T-4G studies referenced earlier, the SIG was felt to be beneficial to the student's training; however, the dimensions of the guide (8½ by 11 inches) was awkward for use by IP's during a sortie. In addition, suggested guidance for use of the advanced instructional feature was not sufficiently precise for quick reference. Although all instructors were checked out on the mechanics of each feature, they tended not to use some features (i.e., record/playback and parameter control) simply because they were not confident in their ability to operate the system correctly and, in some cases, unsure of the potential benefits. As they gained experience, some instructors began using the features more regularly and in more innovative ways.

A suggested guide for use during simulator training would be about the same size as a conventional pilot check list. As a minimum, it should include initial conditions and other advanced instructional features best suited for each maneuver.

V. SUMMARY AND CONCLUSIONS

The effective use of any training device is dependent on the manner in which it is integrated into the syllabus and the way it is used. Considerable experience is available in these areas when using simulators as supplements to UPT instrument and procedures training; however, little information exists concerning the problems involved in developing a syllabus which incorporates a device which has the capability of supplementing all phases of training. This study provided an opportunity for examining the problems involved when integrating the ASPT, a near full mission simulator, into the basic phase of UPT, an operational training program.

While acceptable estimates of training effectiveness were achieved in most phases of UPT through use of the ASPT, several problem areas in training flow were identified which are believed to have prevented achieving more impressive results. The more significant of these occurred as the result of attempting to conduct a training program which incorporated progression on a proficiency basis in all phases of UPT, within the management-directed constraints of an existing program which is conducted on a fixed-schedule basis. The more significant of these problems resulted from requirements; to comply with a fixed academic prerequisite schedule, to comply with the standard graduation day and to schedule aircraft flights two weeks in advance of the required sorties. While these problems may be of only minor significance in a syllabus wherein simulators are only used for instrument training, they are compounded when the training device is used for all phases of training and the phasing of blocks of simulator time is required at several times throughout the training program.

In summary, the syllabus described in this report provides a data base for use by training personnel planners who are involved in integrating a full mission simulator into an operational pilot training program; however, the administrative problems highlighted in this report must be solved if maximum efficiency is to be achieved. The AFHRL Student/Instructor Guide provides a model for use with any training program.

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